LSST Astrophysics/Cosmology

DOE HEP Program Review
April 27, 2005
Brookhaven National Laboratory
Morgan May

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LSST Astrophysics/Cosmology

- Cosmology data → Fundamental Physics
  - Nature of Dark Energy
  - Nature of Dark Matter
- LSST new initiative arrived at after careful study of options. With SLAC, proposed DOE Camera.
- BNL role:
  Science – Focal Plane – Data Management
- Enabled by BNL's HEP core competencies

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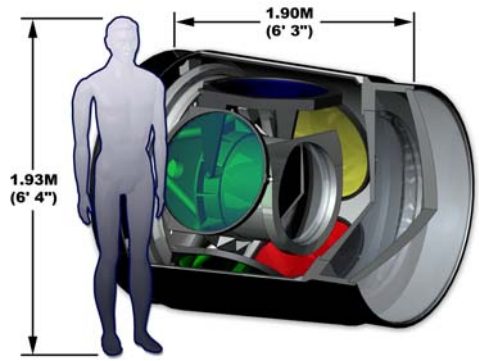
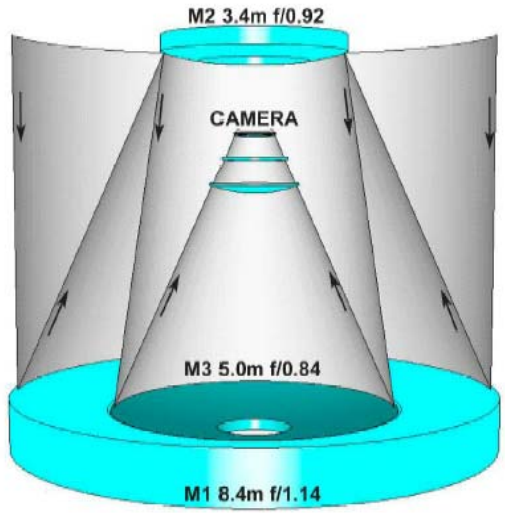
LSST



- Will survey sky 100 times faster than any existing facility; 10 times faster than any proposed
- Versatility
- 10 deg^2 field of view
- 3 Gigapixel focal plane
- Data rate comparable to ATLAS



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Sky Survey Rates

Project	E[m^2deg^2] Light collecting power	E relative	Fraction of year Available	Survey rate per year (relative)
SDSS	5	1.5	1	1.5
DES	30	9	.3	3
Pan-STARRS4	46	14	<1	<14
LSST	318	100	1	100

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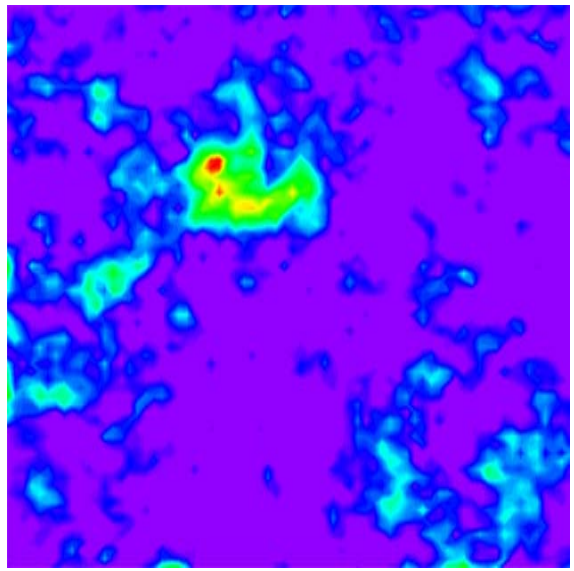
Ingredients of Cosmology

- CMB temperature anisotropies measure density perturbations at single redshift.
- Weak Lensing measures evolution of matter distribution with redshift, determining cosmology
- WL sensitive over the range of z where dark energy is active

- Nature of Dark Energy:
  - Vacuum energy, scalar field or modified gravity?
  - Equation of state of dark energy $P=w\rho$
  - Does w=-1? Is w redshift dependent?

Weak Lensing



•Correlated change in ellipticity of background galaxies induced by foreground masses
•Above galaxy cluster reconstructed by WL: DLS data studied by BNL for filter optimization
•WL detects matter- dark+baryonic - through gravitation, independent of baryonic physics

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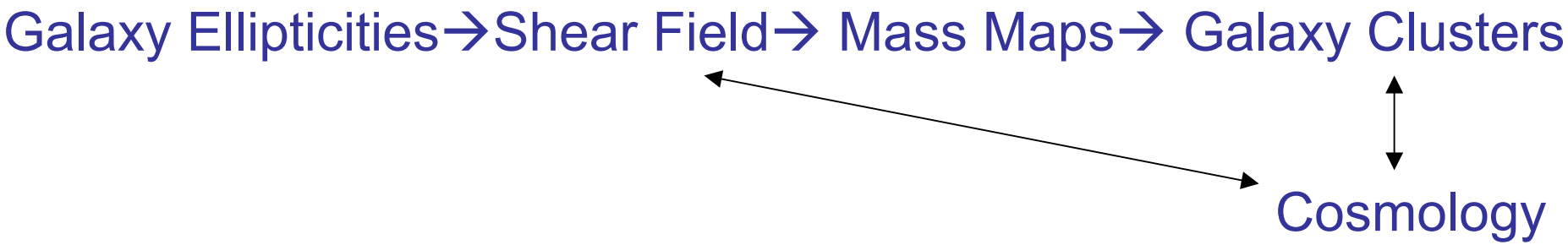
Galaxy Clusters



- Galaxy clusters are the most massive objects in universe, stand out in shear field
- Evolve from highest peaks in the initial density perturbations
- Tracer of growth of structure
- Enhanced correlation (bias)

Dark Energy Properties: w, w_a

PHYSICAL REVIEW D **70,** 123008 (2004)

Constraining the evolution of dark energy with a combination of galaxy cluster observables

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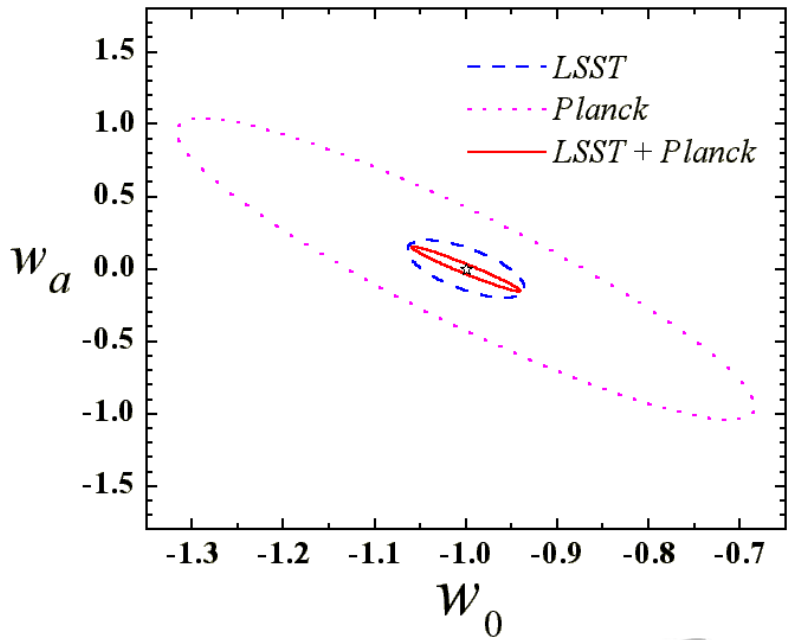
LSST's 200,000 galaxy clusters will tightly constrain dark energy equation of state

P=wρ



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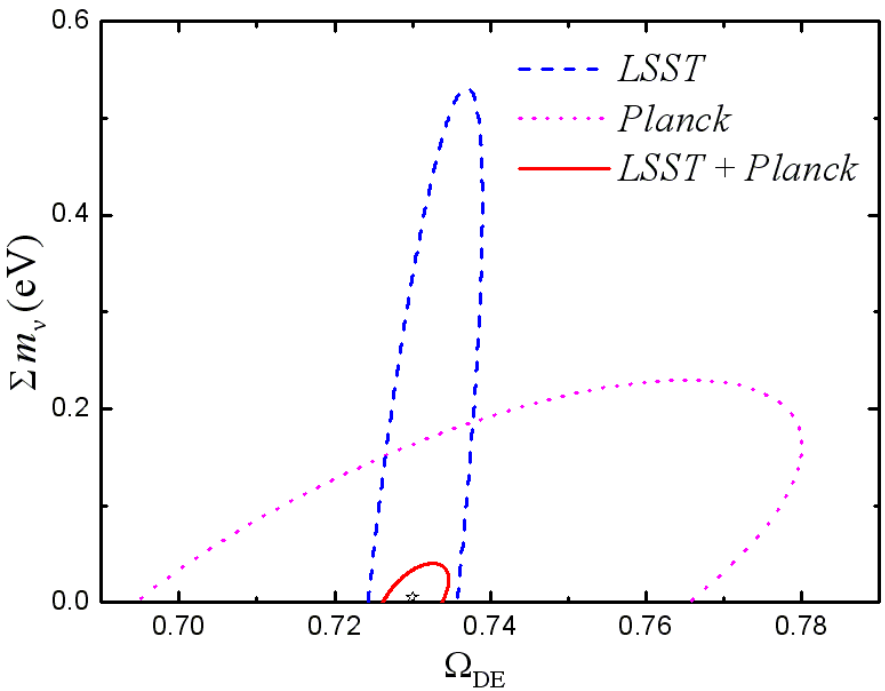
Neutrino Dark matter: m_ν

"Weighing neutrinos with galaxy cluster surveys"

BNL/Columbia/U. Chicago (Wayne Hu)

Submitted for publication

- Cosmology sensitive to Σm_ν breaking the degeneracy of ν oscillation measurements
- ν become non-relativistic →cluster with CDM
- $T_\nu \approx .2$ eV at CMB decoupling → CMB sensitive to $m_\nu > .2$ eV
- LSST+Planck sensitive to $m_\nu > .03$ eV < m_ν atmospheric



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Focal Plane

- BNL-Harvard-CfA team
- No existing sensor meets all specifications
- CCD and hybrid-PIN-CMOS sensors being developed
- Sensor/electronics design to meet science requirements
- Developed strawman design as starting point for negotiations with vendors
- V. Radeka will discuss tomorrow

Focal Plane Requirements

- 3 Gpixels an order of magnitude more than present largest arrays; 200 4K by 4K CCDs, 10μm pitch, 64 cm diameter focal plane
- Good near-IR response at 1000 nm; PSF < .2 arcseconds→100 μm thick sensors
- Fast readout, 2 orders of magnitude higher than previous→ segmentation (64000 readout ports)→ high degree of integration for front end electronics
- Metrology – 5 μm tolerances for sensor flatness and alignment.

Data Management

- BNL/Harvard/Princeton/U Wash Team R&D
  - Pixel level algorithms and prototype photometric pipeline: (BNL detailed knowledge of sensors)
  - Benchmarking pipelines on parallel processors
  - Run image processing analysis on precursor surveys
- Regional LSST computing and analysis center
  - Synergy with BNL ATLAS/RHIC Computing

Future

- LSST collaboration preparing proposal for DOE to be submitted early summer
- 3 years R&D, followed by 4 years construction
- Increase DOE HEP university participation
- Hope for funding that will enable schedule
- Key role for modest size BNL group leveraged by:
  - BNL HEP core competencies
  - Lab infrastructure
  - Collaboration